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drawings are of bud, leaf-scar, pith, and other twig characters upon which the keys are based, so that with the use of a hand lens it should be possible to determine readily the genera, and for the most part the species, for native and introduced trees and shrubs. The author is to be congratulated in making such a fund of unusual information available in such a compact and readily available form.—GEO. D. FULLER.

American trees.—Another book on trees, by EMERSON and WEED,[5] has been added to the already large number upon the same subject. It is essentially a book for the amateur, since its chief virtue lies in the excellent photographs by EMERSON, an entire page being devoted to each species. The absence of keys of any sort renders the book comparatively useless for the identification of an unknown species, but the quality and abundance of the illustrations will make it one the tree lover will wish to have upon his table.—GEO. D. FULLER.

NOTES FOR STUDENTS

Physiological balance in soil and other nutrient solutions.—HIBBARD[6] has just published a piece of work on physiological balance in soil solution which is to mark a decided advance (both theoretically and practically), if the future development of the work approximates its present promise. He extracted the soil solution from an infertile very sandy soil and from a fertile sandy loam by the Van Suchtelen oil pressure method as improved and extended in usefulness by MORGAN.[7] HIBBARD speaks of this as giving a more concentrated solution than any other extraction method. The solution thus extracted from the poor sandy soil had an osmotic pressure of 0.193 atmospheres, and that from the good soil 1.81 atmospheres. The soil extracts showed an order of production similar to the soils from which they came.

The soil extracts were used instead of distilled water to prepare the Shive 3-salt (KH_2PO_4, $Ca(NO_3)_2$, $MgSO_4$) nutrient solution. The total concentration of nutrient salts added gave an osmotic pressure of 1.75 atmospheres, and in the 36 different solutions made up from each soil extract and from distilled water the proportions of each salt varied from 10 to 80 per cent of the total nutrient salt osmotic concentration.

In the nutrient solution made from the extract of the poor soil the optimum osmotic proportions of the KH_2PO_4, $Ca(NO_3)_2$, and $MgSO_4$ for the growth of Fultz wheat were 7:1:2 respectively, with a total osmotic pressure of (1.75+0.193) 1.94 atmospheres; in that made from the extract of the good soil 2:7:1 respectively, with a total osmotic pressure of (1.75+1.81) 3.56 atmospheres; and in that made with distilled water 5:2:3, with a total osmotic pressure of

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[5] EMERSON, ARTHUR I., and WEED, C. M., Our trees, how to know them. New ed. pp. xxi+295. *pls. 149.* Philadelphia: Lippincott Co. $3.50.

[6] HIBBARD, R. P., Physiological balance in the soil solution. Tech. Bull. Mich. Agric. Exper. Sta. no. 40. pp. 44. 1917.

[7] Tech. Bull. Mich. Agric. Coll. Exp. Sta. no. 28.

1.75 atmospheres. Analyses of the soil extract of the poor soil showed it to be proportionally low in K_2O and P_2O_5. Also addition of KH_2PO_4 to the poor soil at the rate of 150–300 pounds to the acre greatly increases the growth of wheat. A similar analysis of the soil extract of the good soil showed it to be as poor in nitrates, nitrites, and ammonium salts as the extract from the poor soil, but with a relatively high calcium magnesium ratio. Addition of $Ca(NO_3)_2$ to the good soil at the rate of 200–400 pounds to the acre greatly improved the growth of the plants. Hibbard concludes that the soil is deficient in calcium and perhaps nitrates. If, as Hibbard's results seem to indicate, one can tell the fertilizer needs of a soil by such a study of the soil extracts, he has given us a new practical method of great significance. He has also hinged the fertilizer question largely on the balance between nutrient ions.

Hibbard worked only on the early stage of the growth of wheat. It would be of interest to know whether the same ratios apply to the middle and late stages. It will also be interesting to see the nature of these ratios when plants with high sulphur demands (alfalfa, cabbage, etc.), those with high potash demands (potato, tobacco, etc.), or those with high general nutrient demands (squash, cucumber, etc.) are used. These stand in contrast with the wheat with its moderate demands. The method also needs the test of a great range of soil types of various degrees of fertility. Considering all of these variables, the application of the method may become rather complex. The work is sure to stimulate a great amount of investigation.

The use of a 3-salt nutrient solution requires that the variation in concentration of the several nutrients shall always be in pairs. In Shive's solution a change in concentration of sulphur is always accompanied by a corresponding change in the concentration of magnesium, potassium by phosphorus, and calcium by nitrogen. There is no reason for thinking that the magnesium demands of a plant are thus tied up with the sulphur demands; in fact, in soils we think of the sulphur as existing mainly as calcium sulphate, and in fertilizer practice it is more generally added in this form. This is not an adverse criticism of the use of 3-salt nutrient solutions; it is rather an acknowledgment of the complexity and innate difficulties of the problem. Since so many variations in proportions of nutrients are possible, the investigator must study only a portion of these, if he completes his investigations within a reasonable time.

Livingston and Tottingham[8] recognize this shortcoming of the 3-salt nutrient solution when they mention the 6 possible combinations of salts and proceed to investigate the best proportions in the second combination. The possible combinations are:

I	II	III	IV	V	VI
$Ca(NO_3)_2$	$Ca(NO_3)_2$	$Ca(H_2PO_4)_2$	$Ca(H_2PO_4)_2$	$CaSO_4$	$CaSO_4$
KH_2PO_4	K_2SO_4	KNO_3	K_2SO_4	KNO_3	KH_2PO_4
$MgSO_4$	$Mg(H_2PO_4)_2$	$MgSO_4$	$Mg(NO_3)_2$	$Mg(H_2PO_4)_2$	$Mg(NO_3)_2$

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[8] Livingston, B. E., and Tottingham, W. R., A new 3-salt nutrient solution for plant cultures. Amer. Jour. Bot. 5:337–346. 1918.

They grew Fulcaster wheat for 18 days in 12 different molecular proportions of the salt combination II. The nutrient solutions had a total osmotic pressure of 1.75 atmospheres. Of the 12 volume molecular proportions tried the following proved best: KNO_3 0.0216, $CaH_2(PO_4)_2$ 0.0026, $MgSO_4$ 0.0150. This finding must not be taken too seriously, however, for it is based on the extremely slim experimental evidence of a single set of cultures with 6 seedlings in each concentration; also very different molecular proportions (KNO_3 0.0036, $CaH_2(PO_4)_2$ 0.0078, $MgSO_4$ 0.0300) gave almost as good results as this optimum and very much better results than the intermediate combinations.

Using combination I (Shive's solution) with a total osmotic pressure of 1.75 atmospheres, SHIVE and MARTIN[9] have determined the optimum volume molecular proportions for the development of buckwheat during its early period of growth (24 days) and during its period of maturity. The following table gives the results based on maximum production of dry weight:

			VOLUME-MOLECULAR PARTIAL CONCENTRATION			YIELD OF TOPS, ROOTS, SEEDS RELATIVE TO THOSE FROM	
			KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	Knop's solution taken as 1.00	Tottingham's solution taken as 1.00
Buckwheat grown to flowering (early growth period)	Water cultures	Tops	0.0144	0.0052	0.0200	1.61	1.33
		Roots	0.0144	0.0052	0.0200	1.58	1.27
	Sand cultures	Tops	0.0144	0.0052	0.0200	1.38	1.25
		Roots	0.0180	0.0104	0.0050	1.47	1.16
Buckwheat grown to maturity (late growth period)	Water cultures	Tops	0.0108	0.0130	0.0100	1.40	1.35
		Roots	0.0108	0.0130	0.0100	1.50	1.39
		Seeds	0.0108	0.0078	0.0200	1.28	1.74
	Sand cultures	Tops	0.0108	0.0130	0.0100	1.40	1.26
		Roots	0.0108	0.0130	0.0100	1.27	1.26
		Seeds	0.0108	0.0130	0.0100	1.24	1.17

It is interesting to see SHIVE's solution far superior to KNOP'S and to TOTTINGHAM's for growth of buckwheat. In former work by SHIVE the maximum growth of wheat tops appeared in the following molecular proportions: KH_2PO_4, 0.0180; $Ca(NO_3)_2$, 0.0052; $MgSO_4$, 0.0150. The $Ca(NO_3)_2$ needs for buckwheat rises greatly in the late growth period, while the KH_2PO_4 and $MgSO_4$ requirements both fall.

Many of the excellent methods used in these 3-salt nutrient solution studies were worked up by MCCALL. MCCALL and RICHARDS[10] summarize their results on wheat in the following table, showing the mean molecular proportions of the 3 component salts and the ionic ratios for the culture solutions giving the best and the poorest growth of wheat during the different periods of development. They promise a full discussion of data with the publication of results of experiments, now being carried on at the Maryland Experiment Station on the nutrient requirements of soy beans and buckwheat.

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[9] SHIVE, J. W., and MARTIN, W. H., A comparison of the salt requirements for young and for mature buckwheat plants in water cultures and sand cultures. Amer. Jour. Bot. 5:186-191. 1918.

[10] MCCALL, A. G., and RICHARDS, P. E., Mineral food requirements of the wheat plant at different stages of its development. Jour. Amer. Soc Agron. 10:127-134. 1917.

Series and growth rank		Mean molecular proportions in tenths of total concentration		
		KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$
Series 1 first period	Best 9	3.4	4.7	1.9
	Poorest 9	3.8	2.0	4.2
Series 2 second period	Best 9	3.5	4.6	1.9
	Poorest 9	2.7	1.5	5.8
Series 3 third period	Best 9	2.0	5.5	2.5
	Poorest 9	6.1	1.8	2.1

All this work indicates that SACHS, KNOP, and others had not nearly exhausted the subject of desirable nutrient solutions for water and sand cultures, but that we still have much to learn. The concentration of the nutrient salts used in these solutions are far above those existing in the general soil solution, and upon the whole the immediate significance of this work in problems of soil fertility is not evident. In the soil the dissolving power of well developed root hairs in contact with nutrients of low solubility introduces a new and important feature. It must be stated, however, that HIBBARD'S work offers indications of an important bearing of this method on questions of soil fertility.—WM. CROCKER.

Respiration and age of plant organs.—NICOLAS[11] has studied the respiration of very young leaves and leaflike structures in comparison with that of the corresponding fully developed organs taken from older parts of the same plants. In a few cases he included also a comparative study of the respiration of sections of the stem or branch bearing the young and old leaves. His material was selected from 15 different species, including annuals, biennials, and perennials. The studies were conducted by the method of confined atmospheres in absence of light at temperatures from 15 to 24° C., the gas analysis being made with the Bonnier-Mangin apparatus. Respiratory intensities were calculated on the basis of the fresh weight of the materials used. The "internal respiration" also was determined in a few cases, using hydrogen atmospheres. Respiratory quotients CO_2/O_2 and the ratio I/N between "internal respiration" and normal

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[11] NICOLAS, G., Contribution a l'étude des variations de la respiration des végétaux avec l'age. Rev. Gen. Botanique **30**: 214–225. 1918.